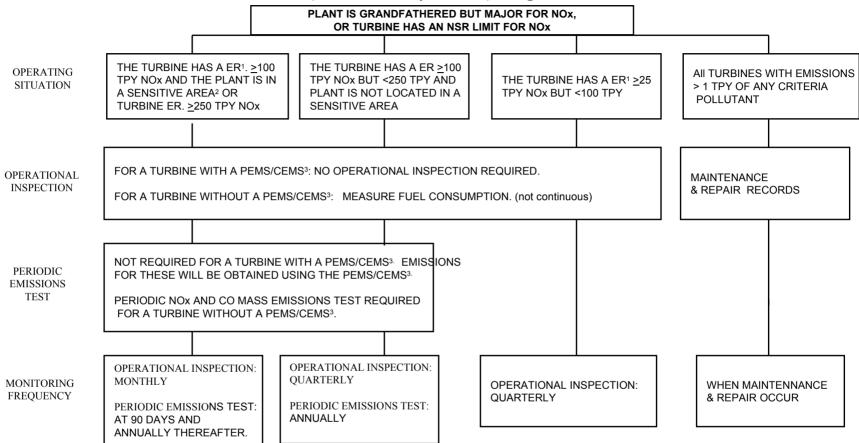
MONITORING FOR TURBINES AT TITLE V SOURCES

(VERSION: May 17, 2005) – Page 1

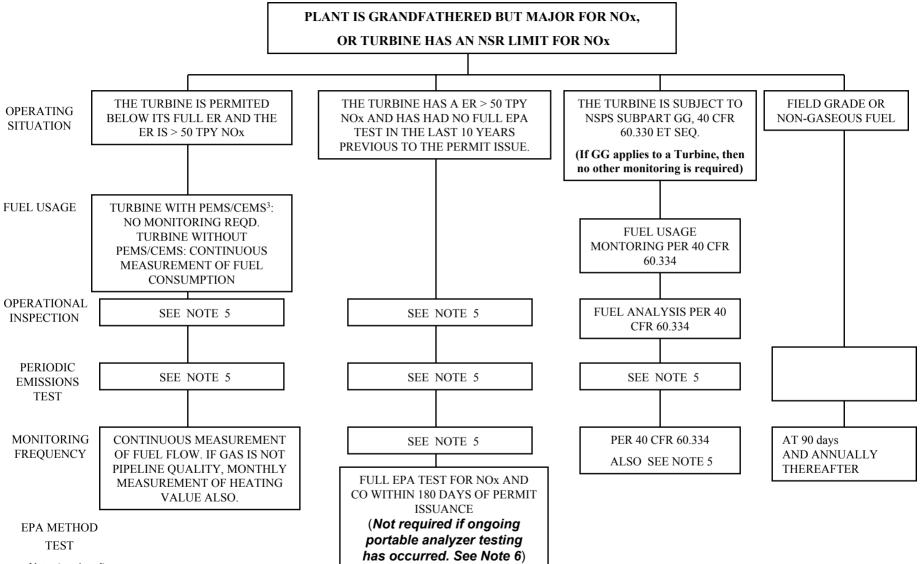


NOTES:

The purpose of this protocol is to determine monitoring requirements for emissions. Operational constraints are monitored by imposing record keeping requirements or other appropriate means.

- 1. Emission Rate, (ER.) for the purpose of this protocol means the emission rate of a turbine at its maximum capacity to emit in the absence of air pollution control equipment which is not vital to its normal operation. If a unit has a permit condition limiting hours of operation or imposing another operational/physical limit, then these limits are included in determining ER.
- A sensitive area is a) a designated restricted area for streamline permit; b) the plant location for a plant
 whose NOx emissions exceed 80% of the NAAQS, excluding background concentrations from other
 plants, c) a non-attainment area for NOx or ozone. See Table 2 of NM/AQB Dispersion Modeling Guidelines –June 1998 or later.
- 3. PEMS/CEMS = predictive (continuous) emissions monitoring system. Also see text.

MONITORING FOR TURBINES AT TITLE V SOURCES (VERSION: May 17, 2005) - Page 2



Notes (continued)

- 4. For multiple units of the same make and model, at least 50% must be tested. Inconsistent test results may cause all remaining units to be tested. All units must be tested if plant is located in a sensitive area.
- 5. See appropriate monitoring in another category on this page or previous page if that category also pertains to the turbine.
- 6. The original purpose of requiring an EPA Method test for engines that were grand-fathered or for which a test had not occurred for ten years was to determine the engines actual emissions. For engines in which current permit conditions exist that require periodic testing using a portable analyzer, the requirement for a EPA Method test every 10 years may not provide any value.

PERIODIC MONITORING GUIDELINES TURBINES LOCATED AT NEW MEXICO TITLE V URCES[jwk1]

<u>Purpose.</u> These guidelines are intended to help Title V permit engineers include adequate periodic monitoring conditions into operating permits in accordance with 20.2.70 NMAC, sections 302.C, 302.D, and 302.E. These guidelines also help ensure consistency in monitoring conditions for all operating permits regardless of the engineer assigned to the permit.

Permit Language.

- 3.4 Emissions Monitoring and Testing Requirements: {See Template for language}
- 3.4.1 General Monitoring Requirements: {See Template for language}
- 3.4.2 Unit Specific Monitoring Requirements: {See Template for language}

Table 3.4.2, Required Monitoring

Emissions Unit Nos.	Parameters To Monitor	To Comply with	Monitoring Required	Monitoring Conditions
Monitoring for Turbines				
1 to 7	Fuel Usage	Operational Requirements specified in section x.x.x	Fuel Usage (Periodic)	3.4.2.1
4	Fuel Usage	Emission limits specified in section x.x.x	Fuel Usage (Continuous)	3.4.2.2
1 to 7	Operations	Emission limits specified in section x.x.x	Install PEMS/CEMS/CEMS	3.4.2.3
1 to 7	NOx, CO, VOC	Emissions Limits specified in section x.x.x	Annual or Quarterly Periodic Emissions Testing	3.4.2.4
1 to 7	Visible emissions	20.2.61 NMAC	Opacity	3.4.2. = 2]
8-10	M&R Activities	Emission limits specified in section x.x.x	Maintenance and Repair	3.4.2.6
13	NOx, CO, VOC	Emission limits specified in section x.x.x	EPA Methods test	3.4.2.7
5,6	As required in 40CFR 60.334, Subpart GG	40CFR 60.334, Subpart GG	Specific requirements of 40 CFR 60.334, Subpart GG	3.4.2.8
1	Fuel Sulfur concentration	40CFR60 Subpart GG, and NSR Condition 3.	Custom Fuel Monitoring Schedule Attachment A to NSR Permit XXX- MX	3.4.2.9

{Apply the following sections, turbine by turbine, as required by the flow charts on pages 1

- and 2.} {If this and any other condition is brought forward from a NSR permit use the following sentence at the end of each condition. "This condition was brought forward from NSR Permit XXX-MX, Condition X."}
- 3.4.2.1 Periodic Operational Inspection Monitoring of Fuel Usage (For Turbine(s), Units **x**, **y**, **x**): The fuel flow rate shall be measured and recorded during the test using a properly calibrated fuel flow meter.
 - (a) The monitoring period shall be a calendar [month, quarter, half year, or year].
 - (b) Initial monitoring will be performed within the first monitoring period occurring after permit issuance.
 - (c) All subsequent monitoring shall occur in each succeeding monitoring period. No two monitoring events shall occur closer together in time than 25% of a monitoring period.

{For a turbine with a PEMS/CEMS/CEMS, no operational monitoring is required, but see 3.4.2.3, below.}

{For a turbine whose fuel consumption needs to be monitored continuously (see flowchart page 2) include the following section:}

3.4.2.2 Continuous Operational Inspection Monitoring of Fuel Usage (For Turbine(s), Units *x*, *y*, *x*): Fuel usage shall be measured with a dedicated fuel meter per turbine.

{For periodic monitoring of a turbine with a PEMS/CEMS/CEMS, use section 3.4.2.3, below:}

3.4.2.3 Predictive Emissions Monitoring (For Turbine(s), Units x, y, x): Predictive Emissions Monitoring system (PEMS/CEMS) shall be carried out at the frequency indicated in the table by the methods described below.

{Installation of a PEMS/CEMS/CEMS on turbines is optional. If the facility intends to install a PEMS/CEMS/CEMS, use the following sections. See <u>Background</u> section of this document for a discussion.}

- 3.4.2.3.1 Turbines {xx, yy, ..., zz} shall be equipped with a properly operating predictive monitoring system (PEMS/CEMS) within 180 days of the date of issue of this permit.
- 3.4.2.3.2 The permittee shall use the PEMS/CEMS/CEMS to calculate a daily average NOx and CO emission rate for each turbine. Time periods during which the turbine is not operating shall not be included in the average. Emissions shall be expressed in pounds per hour.
- 3.4.2.3.3 Within six months of the issue date of this permit, the PEMS/CEMS/CEMS shall undergo a relative accuracy test assessment (RATA) according to NSPS Appendix B, Performance Specification 2. The reference method shall be Method 20 of NSPS Appendix A. The RATA is

waived if the permittee can demonstrate to the Department's satisfaction that the PEMS/CEMS version in use has a reliable history of predicting emission rates from the turbine model under consideration.

{For periodic emissions tests of a turbine without a PEMS/CEMS, use section 3.4.2.4, below:}

- 3.4.2.4 Periodic Emissions Tests Monitoring (For Turbine(s), Units **x**, **y**, **x**): The permittee shall elect to use either EPA Reference Test Methods or sampling by portable analyzer, subject to the requirements and limitations of section **3.4.1**, **General Monitoring Requirements**. For periodic testing, but not for any initial compliance test, periodic **[CO and NOx]** emissions tests shall be carried by the methods described below:
 - (a) The test period shall be a calendar *[month, quarter, or year]*.
 - (b) First Test will be performed within the first test period occurring after permit issuance.
 - (c) All subsequent monitoring shall occur in each succeeding monitoring period. No two monitoring events shall occur closer together in time than 25% of a monitoring period.
- 3.4.2.5 Opacity Monitoring (For Units x, y, x) {When required by 20.2.61 NMAC}: Use of pipeline quality [njj3]natural gas fuel constitutes compliance with opacity requirements. At such time as fuel other than pipeline quality natural gas is used, opacity shall be measured in accordance with the procedures at 40CFR60, Appendix A, Method 9. The monitoring period for opacity measurements shall be a calendar quarter until such time as pipeline quality natural gas is [Figure 1] d[jwk4]. {or adjust schedule as required on a case by case basis}

{For turbines requiring operations and maintenance records use section 3.4.2.6 below.}

- 3.4.2.6 Maintenance and Repair Monitoring (For Turbine(s), Units *x*, *y*, *x*): Maintenance and repair activities that involve adjustment, replacement, or repair of functional components with the potential to affect operation of an emission unit shall be documented as they occur for the following events.
 - (a) Routine Maintenance that takes a unit out of service for more than two hours during any twenty-four hour period.
 - (b) Unscheduled repairs that require a unit to be taken out of service for more than two hours in any twenty-four hour period.

{Use the section below for turbines that require a full EPA emissions test per the flow chart of pages 1 and 2:}

3.4.2.7 EPA Methods [For Turbine(s), Units x, y, x): The permittee shall perform the EPA Methods test requirement for turbines.

{If in addition a turbine is subject to NSPS Subpart GG, 40 CFR 60.330 add the following language. Note that in some cases it may be possible to combine the monitoring and testing

requirements of Subpart GG with some of the above monitoring. Also, the NOx and SO₂ standards at 60.332 & 60.333 should be addressed in the emissions limits section of the permit.}

- 3.4.2.8 40CFR60.334, Subpart GG Monitoring (For Turbines, Units **X, Y, Z**): Turbines subject to NSPS Subpart GG shall comply with the monitoring and testing requirements of 40 CFR 60.334 and 60.335.
- 3.4.2.9 See attachment A "Custom Fuel Monitoring Schedule". {Attach this document to the back of the permit and list in the attachments reference on page 22 of permit [plate[nij6] }
- 3.4.3 Emissions Test Equipment and Procedures (For Turbine(s), Units x, y, x): {When required}
- 3.4.3.1 Test Equipment For Portable Analyzers (For Turbines, Units x, y, x): A portable analyzer may be used instead of the EPA method tests of 40 CFR 60 for periodic emissions tests, but it must be capable of measuring the specified pollutants and O_2 over the full range of expected allowable emissions measurements. The manufacturers specifications of the analyzer(s) to be used shall be submitted to the department for review as part of the emissions test protocol that is submitted to the Department prior to testing.
- 3.4.3.1.1 The fuel flow rate shall be measured and recorded during the test using a properly calibrated fuel flow meter.

The following two conditions are repeated in 3.4.3.2.1.a & c

- 3.4.3.1.2 Turbines shall be tested in the "as found" condition. Turbines may not be adjusted or tuned prior to any test for the purpose of lowering emissions, and then returned to previous settings or operating conditions after the test is complete.
- 3.4.3.1.3 After the time a correlation is established between emission rate and concentration of a pollutant, the periodic emission test may consist of measuring the pollutant concentration. Exhaust flow rate at the time of correlation (by 40CFR60-method 19, by manufacturer's correlation, or by initial testing) may be used to calculate emission rates at later $\boxed{=}$ s[jwk7].
- 3.4.3.2 Analysis and Test Methods (For Turbines, Units *x*, *y*, *x*): The following analysis procedures and test methods shall be performed as part of the emissions monitoring requirements. The permittee shall elect to use either EPA Reference Test Methods or sampling by portable analyzer, subject to the requirements and limitations of the first paragraph of section 3.4 (SEE PERMIT TEMPLATE). {List and describe the analysis procedures and/or test methods that must be performed. See the basic requirements below.} Periodic testing is required for total nitrogen oxides (NOx) and carbon monoxide (CO). (IF FACILITY IS MAJOR FOR VOC's OR NSR PERMIT HAS VOC EMISSION LIMITS, THEN INCLUDE THE FOLLOWING) Test results that demonstrate compliance with the NOx and CO emission limits shall also be considered to demonstrate compliance with the volatile organic compound (VOC) emission limits.
- 3.4.3.2.1 Portable Emissions Analyzer Sampling (For Turbines, Units x, y, x): [1] When a portable emissions analyzer is used to measure emissions, the equipment shall be setup and operated in accordance with the manufacturer's instructions, with the current version of the Department's

Standard Operating Procedure for Use of Portable Analyzers in Performance Tests, and with the following conditions:

- (a) Equipment shall be tested in the "as found" condition. Equipment may not be adjusted or tuned prior to any test for the purpose of lowering emissions, and then returned to previous settings or operating conditions after the test is complete.
- (b) During emissions tests the moisture content, O_2 concentration, flow rate and temperature of the exhaust gas shall be monitored (or calculated by an acceptable method) and recorded. This information shall be included with the test report that is required to be furnished to the Department.
- (c) After the time a correlation is established between emission rate and concentration of a pollutant, the periodic emission test may consist of measuring the pollutant concentration. Exhaust flow rate at the time of correlation (by 40CFR60-method 19, by manufacturer's correlation, or by initial testing) may be used to calculate emission rates at later tests.
- 3.4.3.2.2 EPA Methods [For Turbine(s), Units x, y, x): The following analysis procedures and test methods shall be performed within 6 months of permit issuance, as part of the EPA Methods test requirement.
- 3.4.3.2.2.1 The turbine tests shall be conducted in accordance with EPA Methods 10 (CO) and 20 (NOx) contained in 40 CFR Part 60, Appendix A, and with the requirements of Subpart A, General Provisions, 60.8 (f). The results of the test for nitrogen oxides shall be expressed as nitrogen dioxide (NO₂) using a molecular weight of 46 lb/lb-mole in all calculations. Test results that demonstrate compliance with the NOx and CO emission limits shall also be considered to demonstrate compliance with the VOC emission limits.
- 3.4.3.2.2.2 The permittee shall notify the Department at least thirty (30) days prior to the test date and allow a representative of the Department to be present at the test. The permittee shall arrange a pre-test meeting with the Department at least thirty (30) days prior to the test date and shall observe the following pre-testing and testing procedures:
 - (a) The test protocol and test report shall conform to the standard format specified in the current version of the Department's Standard Operating Procedure: Contents of Stack Test Protocols. The most current version of the format may be obtained from the Enforcement Section of the Air Quality Bureau.
 - (b) The permittee shall provide (a) sampling ports adequate for the test methods applicable to the facility, (b) safe sampling platforms, (c) safe access to sampling platforms and (d) utilities for sampling and testing equipment. The stack shall be of sufficient height and diameter so that a representative test of the emissions can be performed in accordance with EPA Method 1 and Method 20.
 - (c) During compliance tests, the turbine's RPM, fuel consumption rate, horsepower, compressor suction and discharge pressures, compressor suction volume, and compressor horsepower output shall be measured and recorded and shall be included with the test report. If

the fuel gas is other than pipeline quality natural gas, the heat content of the fuel gas shall be determined contemporaneously with the test.

- (d) Where necessary to prevent cyclonic flow in the stack, flow straighteners shall be installed.
- (e) The tests shall be carried out at 90% or greater of the full normal load as stated in this permit, or in the application if not in the permit, and at additional loads when requested by the Department. If the 90% load cannot be achieved, these tests may be conducted at the maximum achievable load under prevailing operating conditions [10]. The load and the parameters used calculate it shall be recorded to document operating conditions and shall be included with the test report that is required to be furnished to the Department.

4.0 RECORDKEEPING

Conditions of 4.0 are pursuant to 20.2.70.302.D NMAC.

- 4.1 General Recordkeeping Requirements {See Template for section 4.1}
- 4.2 Unit Specific Recordkeeping Requirements: {See Template for section 4.2} {If any condition is brought forward from a NSR permit use the following sentence at the end of each condition. "This condition was brought forward from NSR Permit XXX-MX, Condition X."}

{Select from the following list as necessary:}

- 4.2.1 Periodic Operational Inspection Recordkeeping of Fuel Usage (For Turbine(s), Units *x*, *y*, *x*): {Not required for a turbine with a PEMS/CEMS} Records of operational inspections shall show the values of all parameters that will be required to be recorded by {3.4.2.1, etc. as applicable}. The permittee shall also note the type of fuel fired (pipeline quality natural gas, field gas, etc.), and append a contemporaneous fuel analysis if the gas is other than pipeline quality natural gas.
- 4.2.2 Continuous Operational Inspection Recordkeeping of Fuel Usage (For Turbine(s), Units x, y, x): {For turbines required by condition 3.4.2.2 to monitor the fuel} Records of fuel usage shall include the make and model of the fuel flowmeter, all charts generated by the flowmeter, the type of fuel fired (pipeline quality natural gas, field gas, etc.), a contemporaneous fuel analysis if the gas is other than pipeline quality natural gas, and all instrument calibrations. The record shall include a flow diagram showing the configuration of the flow meter relative to the turbine.
- 4.2.3 Periodic Mass Emissions Tests Recordkeeping (For Turbine(s), Units *x*, *y*, *x*): {Not required for a turbine with a PEMS/CEMS} Records of periodic mass emissions tests shall include the turbine's fuel flow rate and horsepower at the time of the test, and the type of fuel fired (pipeline quality natural gas, field gas, etc.).
- 4.2.3.1 If a combustion analyzer is used to measure NOx, CO, and/or excess air in the flue gas, records shall be kept of the make and model of the instrument and instrument calibration data. If an ORSAT apparatus or other gas absorption analyzer is used, the permittee shall record all calibration results.

- 4.2.3.2 Records shall be kept of all raw data used to determine flue gas flow and of all calculations used to determine flow rates and mass emissions rates.
- 4.2.4 Turbines with a PEMS/CEMS (For Turbine(s), Units x, y, x): Records shall be kept showing the hourly NOx and CO emission rates and the key parameters used by the PEMS/CEMS to calculate the emission rates.
- 4.2.5 Opacity Recordkeeping (For Units x, y, x): The permittee shall record dates and duration of use of any fuel other than pipeline quality natural gas and the corresponding opacity measurements.
- 4.2.6 Maintenance and Repair Activities Recordkeeping (For Turbine(s), Units **x**, **y**, **x**): Records of maintenance and repair activities shall be maintained. Records of maintenance and repair activities shall include identification of emission units and the work involved.

{If in addition a turbine is subject to NSPS Subpart GG, add the following language. Note that in some cases it may be possible to combine the record keeping requirements of Subpart GG with the some of the above record keeping:}

- 4.2.7 EPA Methods Test Recordkeeping (For Turbine(s), Units *x*, *y*, *x*): Records of EPA Methods tests shall be maintained for the turbines.
- 4.2.8 40CFR60.334, Subpart GG Recordkeeping (For Turbines, Units **X, Y, Z**): Turbines subject to NSPS Subpart GG shall comply with the recordkeeping requirements of 40 CFR 60.334.

5.0 REPORTING

- 5.1 General Reporting Requirements: {See Template for section 5.1}
- 5.1.3 Emissions Test Notification (For Turbines/Engines): {Add this section if emissions tests are required} Protocols for emissions tests shall be submitted to the Department at least thirty (30) days prior to the scheduled test date. Content of the test protocols shall be reported according to the current version of the Department's Standard Operating Procedure for Contents of Stack Test Protocols. If information remains the same as previously submitted protocols, test protocols shall reflect that fact and show only new information. This condition is pursuant to 20.2.70.302.E NMAC.
- 5.2 Unit Specific Reporting Requirements: {See Template}

{The following conditions should correspond to the monitoring and recordkeeping subsections, e.g. If there is no reporting then state that there is none.} {If any condition is brought forward from a NSR permit use the following sentence at the end of each condition. "This condition was brought forward from NSR Permit XXX-MX, Condition X."}

{Select from the following list as necessary:}

5.2.1 Periodic Operational Inspection Reporting of Fuel Usage (For Turbine(s), Units x, y, x):

- {Operational inspections are not required for turbines with a PEMS/CEMS} The permittee shall report fuel used noting any adjustments needed to bring the turbine into compliance with permit ditions[jwk11].
- 5.2.2 Continuous Operational Inspection Reporting of Fuel Usage (For Turbine(s), Units **x**, **y**, **x**): **{For turbines required by condition 3.4.2.2 to monitor the fuel}** Fuel usage reports shall show the average amount of fuel consumed by each affected turbine for every calendar month, expressed in MMBTU/hour.
- 5.2.3 Periodic Mass Emissions Tests Reporting (For Turbine(s), Units x, y, x): {Not required for turbines with a PEMS/CEMS} Reports shall be according to the current version of the Department's Standard Operating Procedure for Stack test reports (example attached to this $mit_{[jwk12]}$).
- 5.2.4 Turbines with a PEMS/CEMS Reporting (For Turbine(s), Units x, y, x): Periodic reports for turbines with a PEMS/CEMS shall summarize in tabular form the average NO_X and CO emissions for each day of the reporting period in pounds per hour. Time periods during which the turbine is not in operation shall be excluded from the average.
- 5.2.5 Opacity Reporting (For Units *x*, *y*, *x*): The permittee shall report dates and duration of use of any fuel other than pipeline quality natural gas and the corresponding opacity measurements (if any).
- 5.2.6 Maintenance and Repair Reporting (For Turbines, Units **X, Y, Z**):

[For new permits, enter the following:]

These reports shall include a summary of the activities in section **4.2.6**, including a copy of the manufacturer's or permittee's recommended maintenance schedule with the initial report submitted for this Title V permit.

[For modifications or renewals, enter the following:]

These reports shall include a summary of the activities in section 4.2.6.

5.2.7 EPA Methods Test Reporting (For Turbines, Units **X, Y, Z**): EPA Methods Test results shall be reported in accordance with the current version of the Department's Standard Operating Procedure for Content of Stack Test orts[jwk13].

{If in addition a turbine is subject to NSPS Subpart GG, 40 CFR 60.330 et seq., add the following language. Note that in some cases it may be possible to combine the periodic monitoring requirements of Subpart GG with the some of the above reporting requirements:}

5.2.8 40CFR60.334, Subpart GG Reporting (For Turbines, Units **X, Y, Z**): Turbines subject to NSPS Subpart GG (40 CFR 60.330) shall comply with the reporting requirements of 40 CFR 60.7.

BACKGROUND INFORMATION

(Not for inclusion in permit)

In New Mexico, turbines are found almost exclusively at mainline compressor stations, oil refineries, and natural gas processing plants. Turbines are also located at power generation plants but these are generally external combustion units. Most medium sized turbines (about 1000 HP through about 15,000 HP) in New Mexico were built by Solar Inc. of San Diego, CA, a division of Caterpillar Engines. General Electric built mostly larger turbines. This document will only discuss gas-powered turbines.

Regulatory Requirements. There are no state regulations that apply specifically to turbines. 20.2.33 NMAC has occasionally been applied to very large turbines (larger than about 18,000 HP). Recently, however, EPNG has challenged the applicability of 20.2.33 NMAC to turbines. NMED's legal staff has examined the hearing transcripts and it appears that since only boilers were mentioned and not turbines, 2.33 will no longer be applicable to turbines. A final decision is expected in April 1997.

NSPS Subpart GG (40 CFR 60.330 et seq.) applies to turbines whose heat input ≥10 MMBTU/hour and for which construction or modification commenced after October 3, 1977. The regulation limits the NOx and SO2 concentrations for affected turbines. Unfortunately, Subpart GG is seriously out of date and fails to account for the enormous changes in turbine design made since the regulation's original promulgation in 1979.

Operating Principles of Natural Gas Turbines. Most turbines at New Mexico oil and gas plants are of the <u>simple cycle</u> type and the majority of these are two-shaft units. Figure 1 shows a simplified schematic of a simple-cycle, two-shaft turbine. In a simple cycle turbine, the turbine's front-end compressor first compresses inlet air. The compressed air enters a combustor where natural gas is injected and ignited. The heat of combustion raises the temperature and pressure of the compressed air. The gas' newly acquired thermal energy is converted to kinetic energy (i.e. work) by expanding the heated air through a set of aerodynamically designed turbine blades arranged around a shaft. Part of the shaft's energy is used to drive the front-end air compressor and the remaining energy is available for external work, usually to drive a natural gas compressor.

In a <u>two-shaft</u> simple cycle turbine, the turbine that drives the front-end air compressor is decoupled from the turbine that provides the useful work, thereby allowing for variable speed applications.

A <u>combined-cycle</u> turbine uses the turbine's exhaust heat to generate steam to drive a secondary steam turbine, thereby improving the thermal efficiency of the turbine. A <u>recuperative-cycle</u> turbine uses the turbine's hot exhaust to preheat the incoming air, thereby also improving the turbine's overall thermal efficiency.

<u>Character of Emissions.</u> The principal pollutants from a turbine are NOx and SO2. The latter pollutant occurs only from turbines using fuels other than pipeline quality natural gas. CO and unburned hydrocarbons (UHC) can be found in the turbine exhaust, but these are rarely the subject of regulatory concern.

NOx from turbines is exclusively thermal NOx. The high combustion temperatures found in a

turbine ensure the copious production of NOx. In simple cycle turbines at least, NOx increases with increasing load while CO and UHC decrease. Figure 2 shows the pollutant concentration trend, normalized to 15% exhaust gas oxygen, for a so-called typical turbine. According to Mr. Wilfred Hung, an engineer with Solar Turbines, Inc. and the author of numerous papers on NOx emissions from turbines, the linear NOx trend shown in Figure 2 is the exception, not the rule.

<u>Predictive Emissions Monitoring Systems (PEMS/CEMS)</u>. PEMS/CEMS for turbines falls into two broad categories. The first, statistical PEMS/CEMS, relies on statistical data obtained from many similar turbines to predict NOx emissions. These emissions are predicted as a function of turbine load. This type of PEMS/CEMS lacks the flexibility to adjust NOx predictions as the turbine's operating parameters change, for example barometric pressure or humidity. The general availability of statistical PEMS/CEMS packages is unknown at this time.

The second form of PEMS/CEMS, first principles PEMS/CEMS, relies on a fundamental thermodynamic model of the combustion process to predict NOx emissions. First principle PEMS/CEMS relies on sensors located throughout the turbine as input to the thermodynamic model. This form of PEMS/CEMS is capable of adjusting its prediction of NOX emissions as the turbine's operating parameters change. First principles PEMS/CEMS is at a sufficiently advanced state of development that many have passed the RATA of NSPS Appendix B.

A third form of PEMS/CEMS is a hybrid of the first two. Emissions data from a particular turbine are used to "calibrate" the thermodynamic model in order to obtain a more precise prediction of NOx emissions.

A fundamental problem with any PEMS/CEMS is that it cannot easily take into account the effects of turbine wear and tear. As turbines age, blades wear down and internal deposits occur that decrease the turbine efficiency. The additional fuel required to overcome these defects changes the NOx emissions and may not be fully accounted for by the PEMS/CEMS. Fortunately, changes to NOx emissions from these defects are not expected to be very large.

Solar Turbines. Mr. Hung of Solar Turbines in San Diego, CA, stated that Solar provides PEMS/CEMS programs for every turbine that the company manufactures, regardless of the turbine's date of construction. Michelle Long, a Solar permitting engineer (619-694-1602), said that the cost of providing the PEMS/CEMS software for a new or recent vintage Solar turbine was \$35K to \$40K per turbine. Whether or not the PEMS/CEMS software is installed, all new and recent vintage Solar turbines come equipped with the sensors that provide the data used as PEMS/CEMS input. Solar turbines older than about 8 years would need the sensors installed.

Solar's PEMS/CEMS is of the first-principles type that relies on only two variables to completely characterize the emission profile of a turbine. For Solar's simple-cycle, two-shaft turbines, these two variables are T₁, the ambient air temperature, and T₅, the power turbine inlet air temperature. Figure 1 shows the location of these temperatures. These temperatures are easily and accurately measured, and when fed into a computer program, give reliable NOx and CO emission rates.

<u>General Electric Turbines</u>. General Electric offers its trademarked GTPEMS/CEMS system to predict NOx emissions from GE turbines. GTPEMS/CEMS is a hybrid model that uses "real" data to calibrate the first-principles model. According to a GE brochure, GTPEMS/CEMS is

available for all GE turbines. Mr. Chris Forland of GE Reuter-Stokes in Cleveland, OH, stated that the company charges about \$150,000 to outfit an existing turbine with GTPEMS/CEMS. The cost of outfitting additional turbines at the same site is about \$100,000 each.

JUSTIFICATION

(Not for inclusion in permit)

<u>Operational Inspection</u>. Operational inspections are separated into two classes: the first class consists of those turbines that <u>do</u> or will be required to have a PEMS/CEMS and the second class those that <u>do not</u> have a PEMS/CEMS and will not be required to have one.

Operational inspections for turbines with a PEMS/CEMS are <u>not required</u> because the PEMS/CEMS itself automatically carries out the operational inspection. Temperatures in various zones of the turbine train as well as turbine speed are continually displayed and recorded

Turbines without a PEMS/CEMS will need to undergo periodic checks of fuel consumption.

<u>Requirement for a PEMS/CEMS</u>. Due to its high cost, the Bureau will not require a PEMS/CEMS for turbines.

Flue Gas CO and NOx Mass Emission Rate Measurements Using a Portable Analyzer. As explained in the background section of this document, with PEMS/CEMS as the primary compliance tool, very little information is to be gained from the use of a portable analyzer to measure species mass emissions from a turbine. Only the larger turbines without a PEMS/CEMS will be required to have periodic mass emissions tests.

<u>Full EPA Stack Test.</u> An initial full stack test based on EPA methods is recommended initially for turbines that have not had a stack test in the ten years prior to permit issue.

<u>Requirement for RATA on PEMS/CEMS</u>. A PEMS/CEMS, like a CEMS, should be certified before accepting its results. The RATA may be waived for PEMS/CEMS with a proven track record for the particular type of turbine in question.

REFERENCES

- 1. <u>Predictive Emission Monitoring System (PEMS/CEMS): The Established NOx Monitoring System for Industrial Gas Turbines</u>, Wilfred S.Y. Hung, Solar Turbines Inc., San Diego, CA, paper presented at 88th Annual AWMA Meeting, San Antonio, TX, June 1995;
- 2. <u>Code of Federal Regulations</u>, Title 40, Part 60, Subpart GG (Standards of Performance for Stationary Gas Turbines), 60.330 et seq;
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